# FIELD WORKER EXPOSURE TO CHLOROTHALONIL WHILE PICKING BUSH GROWN TOMATOES IN STANISLAUS COUNTY CALIFORNIA

By

Frank A. Schneider, Associate Environmental Hazards Scientist
Janet R. Spencer, Environmental Hazards Scientist
Stanley R. Bissell, Environmental Hazards Scientist
Sheila Margetich, Agricultural Chemist

HS-1462 Issued December 20, 1988
Revised September 28, 1989

California Department of Food and Agriculture
Division of Pest Management, Environmental
Protection and Worker Safety
Worker Health and Safety Branch
1220 N Street, P.O. Box 942871
Sacramento, California 94271-0001

## SUMMARY

The fungicide chlorothalonil is under review because of carcinogenicity in laboratory animals. This study was conducted to develop data on worker exposure for health risk assessment and to evaluate mitigation measures. Worker exposure to chlorothalonil was monitored using handwashes after working with and without waterproof gloves. Long sleeve undershirts and socks were worn by the workers to serve as dosimeters. Workers wore the long sleeve undershirt under their normal work shirts. Socks were worn in place of their own socks. Mean exposure measurements were 2.09 mg/hr for all workers monitored on the two days. This mean exposure represents an annual average daily dose of 11.8 ug/kg/day, using a seven hour work day and 120 working days a year.

No significant effect of the gloves on total exposure received by the workers was found. A significant glove effect was associated with the hand exposure. Hand exposure accounted for less than ten percent of the total exposure; mean exposure to the hands was reduced over 80 percent by the use of gloves. Workers found the use of waterproof gloves unacceptable because of discomfort due to sweating. The workers also objected to wearing the gloves because they felt picking tomatoes and carrying the buckets became more difficult. Waterproof gloves do not appear to be a practical means of exposure mitigation.

## INTRODUCTION

Chlorothalonil is a broad spectrum fungicide used on ornamental, orchard and field crops. The California Department of Food and Agriculture (CDFA) is reviewing chlorothalonil exposure because of possible carcinogenic effects seen in laboratory animals. These adverse effects show chlorothalonil to be a possible carcinogen. Chlorothalonil is of low mammalian acute toxicity with an $LD_{50}$ of >16 g/kg in the rat, a dermal $LD_{50}$ in rabbits > 14 g/kg, and an inhalation $LC_{50}$ of 0.35 mg/L in rats (chlorothalonil risk characterization, 1988). It is also a mild skin irritant, possible skin sensitizer and a severe eye irritant.

This study was conducted to characterize worker exposure to chlorothalonil and to evaluate the protection afforded by waterproof gloves. The data will be used for a health risk assessment for agricultural workers exposed to the pesticide and evaluation of possible exposure mitigation measures. Workers picking bush grown tomatoes were chosen as subjects because 33 percent of the chlorothalonil used in California is on tomatoes.

Monitoring of worker exposure was conducted using handwashes, long sleeve undershirts and socks for dosimeters. Long sleeve undershirts were worn under their normal work shirts and socks were worn in place of their own socks for dosimetry. Normal work clothing is usually a long or short sleeve shirt, long pants, shoes and socks.

Total mean exposure for all workers wearing normal work clothing was 2.09 milligrams per hour (mg/hr). In the exposure situations where workers wore gloves and long sleeve work shirts, the highest exposure was less than 1 mg/hr. Arm exposure, measured using the cloth undershirt, accounted for over 85 percent of the total mean exposure.

## MATERIALS AND METHODS

The cooperator located a tomato field in Stanislaus County that had been treated twice with chlorothalonil, five days and thirty-three days before the worker exposure study. The two applications used Bravo 500 (4.17 pounds per gallon chlorothalonil) at the rate of 3 pints or 1.5 pounds active ingredient per acre in 10 gallons of water. A crew of twenty-six workers was monitored on two consecutive days. All crew members were male. None of the workers normally wore gloves when they picked tomatoes. All but three workers reported wearing clean clothes each day. Three workers wore long sleeve work shirts on both days and three other workers wore long sleeve shirts on one day the rest wore short sleeve work shirts. All workers wore shoes and long pants. For dosimetry, workers were provided with long sleeve cotton undershirts to be worn under their normal work shirts. Socks were in place of their own socks. Dosimetry measurements from socks and cotton undershirts without long sleeve work shirts are of the bare skin. The workday length was determined by the number of filled tractor-trailer sized gondolas that the packing house required each day. A workday is five to seven hours and begins at approximately 6:30 each morning. The bush tomato harvest season in the San Joaquin Valley, from Fresno to Stanislaus counties, is from June to November first. A maximum estimate for exposure would be seven hours a day and a 120 days in a year. Many of the crew members had worked for the cooperator in previous years. Some of the

workers lived in the area, while others spent part of the year in Mexico and traveled north for each tomato harvest season.

The field was 120 acres and the rows were approximately 1/2 mile long. The tomato beds were 38 inches wide and the plants were about 18" tall. The tomatoes were picked green for fresh market. Each crew member picked from a single row for the length of the field. The workers were provided with two picking buckets, which weighed approximately 30 pounds each when filled. The average worker filled 120 buckets per day and a fast worker in a field with good yield could fill 200 buckets in a day. The crew members were scattered, one worker per row, to either side of the gondola. The gondola was positioned ahead of the workers and was pulled to a point further down the row as the harvesters worked toward it. It took an average of 5 minutes to fill the two buckets. The filled buckets were carried to the gondola and handed up to one of the dumpers stationed on plank platforms running the length of the gondola. A third person on each side of the gondola punched the harvester's card to document receipt of each pair of filled buckets. While picking, workers bent over each plant. Hands and forearms contacted the fruit and vines as they picked the tomatoes. Vines were flipped over to retrieve fruit lying underneath. Stems were removed from each tomato to minimize bruising and puncture wounds to the fruit during transport. The harvesters' lower legs also contacted foliage as they picked and as they moved across the rows to dump their buckets into the gondola. The crew of 26 filled a gondola in about one hour. It took 10 to 20 minutes to change gondolas during which time workers took breaks. They squatted or sat between the rows and often ate their meals at these times. None of the workers was observed to wash before eating.

To assess hand exposure to chlorothalonil, the workers were divided into two groups. On day 1, workers in one group wore gloves while the workers in group two did not. On day 2, the groups were reversed. Additionally, all workers wore long sleeve cotton shirts and socks under their normal work clothing on both days.

Hand exposure was measured by using a wash of 900 ml of a one percent dioctyl sodium sulfosuccinate solution for each worker. The plan of the study was to have all workers wear waterproof gloves for an entire workday, but after thirty minutes they complained of heat and sweating because of the gloves. After a brief discussion, they agreed to wear the gloves until they filled two tractor trailer size gondolas, which took two hours. Workers washed their hands in 3 liter containers for at least two minutes. The rinsate was then poured off into one liter containers. Workers continued to wear the long sleeve undershirts and cotton socks supplied to measure dermal exposure until the end of the workday. At the end of the day after washing the hands of workers not wearing gloves, all workers removed the socks and undershirts, placing the socks in plastic bags. Sleeves were cut off the shirt and put in one plastic bag and the torso section in another. All samples were stored in the field on dry ice, then kept in a -10°F freezer until analysis by CDFA chemists.

During each day of the study, a foliage sample was taken from each row where an ungloved worker was harvesting tomatoes and analyzed for dislodgeable residues. A 2.54 cm diameter Birkestrand leaf punch was used to collect 40 punches from each row. Also, one total leaf sample of sixteen leaves and two fruit samples were taken from the field. Leaf and fruit samples were placed

on ice and shipped to the CDFA laboratory the same day. Dislodgeable foliage samples were extracted within twenty four hours.

Analysis of all samples was conducted by California Department of Food and Agriculture Chemistry Laboratory Services, Worker Health and Safety Section. Dislodgeable residues were first washed with 50 mls of distilled water and 0.2 mls of 2 percent dioctyl sodium sulfosuccinate solution. The aqueous solution of dislodgeable fruit residues, total fruit residues and hand washes were extracted using ethyl acetate, dried with anhydrous sodium sulfate, diluted as necessary and analyzed using an HP 5880A gas chromatography. Clothing residues were extracted using ethyl acetate. Full details of all procedures may be obtained by contacting the Department of Food and Agriculture Chemistry Laboratory.

## RESULTS

Exposure data, adjusted to hourly exposure values, are shown in Table I. A total hourly exposure was calculated by dividing the amount of pesticide found on each dosimeter (undershirt torso and arms, socks and handwashes), by the hours exposed and summing the areas of the four body regions. Table II summarizes the data for all workers on both days. These figures are representative of exposure for all areas measured except the hands. Hand exposure includes data from workers wearing gloves and not wearing gloves. Table III summarizes the glove data. The data in Tables II and III show that most exposure occurs to the arms in this study.

The analysis of variance (Steel and Torrie, 1980) indicates no significant difference in total exposure with versus without gloves. There was a significant decrease in hand exposure with versus without gloves. Figures 1 and 2 graph the frequency distribution for total exposure and hand exposure, respectively, for workers wearing gloves and not wearing gloves.

Hand exposure data indicate a significant residual effect. This can be seen in Figure 3. Even with the variation in the data, it is clear that the workers had lower residues in their handwashes when gloves were worn. Group one had higher residues in their handwashes on day two when gloves were not worn than group two on day one when they did not wear gloves. Day two had higher dislodgeable leaf residues than day one accounting for the increase in handwash residues.

The effects of gloves worn with long sleeve work shirts is illustrated in Figure 4. The workers without gloves wearing long sleeve shirts received total exposures similar to workers in short sleeve shirts. The five workers wearing both long sleeve work shirts and gloves received significantly less exposure. Exposure for workers wearing gloves without the long sleeve work shirt were similar to all other exposures

Dislodgeable residue data from leaf samples is reported in Table IV. A transfer coefficient factor as explained by Zweig, Leffingwell and Popendorf, 1985, was calculated to be 685 $cm^2/hr$. This is a ratio of the dermal dose rate, 2.09 mg/hr to the dislodgeable foliar residue, 3.05 $ug/cm^2$. This is less than the factors calculated by Zweig et al., 1985. Their study used cotton gloves to measure hand exposure and did not employ handwashes. Hand exposure accounted for 60 to 80 percent of the total dermal exposure in their study and only 10 percent of the total exposure in

this study explaining the difference in transfer factors. Based on the data collected in this study, there is not enough evidence to suggest a linear relationship between dislodgeable foliar residue and total exposure. The leaf total, fruit dislodgeable and total fruit sample had results of: 639.58 ug/12.15 g of leaf or 52.64 ppm for leaf total, 28.49 ug/1,220.2 g of fruit or 0.023 ug/g for fruit dislodgeable, and 25.35 ug/1,232 g of fruit or 0.021 ug/g for total fruit.

## DISCUSSION

The unwillingness of the workers to wear the waterproof gloves the entire work day necessitated normalizing results to an hourly basis. Observation in the field noted that the forearms of ungloved workers were visibly dirty after working a short period of time. Long sleeve work shirts would ride up the arm about 2 to 4 inches directly exposing the undershirt used as a dosimeter. When workers wore gloves, this 2 to 4 inch area stayed covered for two hours. Two of three workers wearing long sleeve work shirts, (Worker #22 and 23, Table I) had arm exposure reduced by half on day two. In the third case, (Worker #16) arm exposure was the second lowest exposure for the two days. Only Worker #7 was willing to wear waterproof gloves all day. In other studies conducted by this Branch, gloves have been more acceptable to workers handling very ripe fruit while working on a mechanical tomato harvester Schneider et al., 1988 or workers picking pole tomatoes. Pole tomato workers preferred to use a 100 percent nylon-cotton blend glove (Rech et al., 1988). If required, workers picking bush tomatoes would wear gloves, but overall acceptability might depend on the type of glove chosen. Field observations of 125 workers at the time the study was initiated found only two workers wearing gloves. The workers felt the gloves were uncomfortable, and made it difficult to pick tomatoes and to carry the two buckets that weigh 30 pounds each when full. No correlation was seen between the dislodgeable plant residues and total worker exposure. Within-row variation was not measured, only across row. Possibly more sampling within the rows would have led to an identifiable relationship. The fruit samples suggest that all residues are found on the surface since the dislodgeable and the total fruit residue results are so close on a microgram per gram basis. This may be of interest when looking at dietary exposures and residues. The bush grown tomatoes go through a vigorous washing after harvest. They withstand this treatment because they are picked green and are still very firm. Residues available after this processing were not quantified.

The mean total exposure was used to calculate an annual average daily dose of 11.8 ug/kg/day and a lifetime adjusted daily dose of 6.74 ug/kg/day. The calculation took into account a seven hour work day, the possibility of working a maximum 120 days a year (based on interviews in the field) and a dermal absorption rate of 13.4% (Blewett et al, 1988).

## REFERENCES

Blewett, T.C. and R.I. Krieger. 1988. Estimation of Exposure of Persons in California to Pesticide Products that Contain Chlorothalonil and Estimation of Effectivness of Exposure Reduction Methods. Worker Health and Safety Branch, HS-1475.

Chlorothalonil Risk Characterization. 1988. Division of Pest Management, Environmental Protection and Worker Safety Branch, California Department of Food and Agriculture. (Draft Report).

Rech, C., S. Bissell, L.P. O'Connell, and S. Margetich. 1988. Worker Exposure to Chlorothalonil Residues During The Harvest of Fresh Market Pole Tomatoes. California Department of Food and Agriculture, Worker Health and Safety Branch, HS-1456.

Schneider, F., J. Spencer, S. Bissell, and S. Margetich. 1988. Chlorothalonil Exposure to Workers on Mechanical Tomato Harvesters. California Department of Food and Agriculture, Worker Health and Safety Branch, HS-1466.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics. McGraw-Hill Book Company, Inc., New York.

Zweig, Gunther, Leffingwell J.T. and Popendorf, William. 1985. The Relationship between Dermal Pesticide Exposure by Fruit Harvesters and Dislodgeable Foliar Residues. J. Environ. Sci. Health, B20(1), 27-59.

**TABLE I**

FIELD WORKER EXPOSURE TO CHLOROTHALONIL
WHILE PICKING BUSH GROWN TOMATOES

| ID | WORKER GROUP | DAY | GLOVE | LONG-SLEEVE | SOCKS | Chlorothalonil ( ug / hr ) TORSO | ARMS | HANDS | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 2 | N | N | 42.5 | 19.8 | 1845.5 | 245.6 | 2153.5 |
| 2 | 1 | 2 | N | N | 10.5 | 68.7 | 1309.1 | 526.5 | 1914.9 |
| 3 | 1 | 2 | N | N | 12.4 | 59.3 | 1230.4 | 362.9 | 1664.9 |
| 4 | 1 | 2 | N | N | 66.4 | 67.1 | 1817.1 | 297.8 | 2248.4 |
| 5 | 1 | 2 | N | N | 26.7 | 12.7 | 2621.5 | 162.7 | 2823.6 |
| 6 | 1 | 2 | N | N | 250.0 | 65.6 | 3395.8 | 129.5 | 3840.9 |
| 7 | 1 | 2 | N | N | 69.8 | 52.2 | 327.6 | 411.3 | 860.9 |
| 8 | 1 | 2 | N | N | 12.9 | 4.4 | 2232.9 | 206.0 | 2456.3 |
| 9 | 1 | 2 | N | N | 15.2 | 57.6 | 2052.7 | 142.2 | 2267.7 |
| 10 | 1 | 2 | N | N | 35.8 | 819.3 | 4066.0 | 445.8 | 5366.9 |
| 11 | 1 | 2 | N | N | 85.8 | 5.9 | 1452.2 | NS | NT |
| 12 | 1 | 2 | N | N | 138.5 | 15.3 | 4655.3 | 131.6 | 4940.7 |
| 13 | 1 | 2 | N | N | 25.5 | 57.8 | 3126.0 | 107.8 | 3317.1 |
| 14 | 1 | 2 | N | N | 2.7 | 11.3 | 544.2 | NS | NT |
| 15 | 1 | 2 | N | N | 51.5 | 21.1 | 380.7 | 98.4 | 551.6 |
| 16 | 2 | 1 | N | Y | 12.2 | 1.7 | 171.5 | 143.2 | 328.7 |
| 17 | 2 | 1 | N | N | 229.8 | 5.3 | 1737.9 | 210.1 | 2183.0 |
| 18 | 2 | 1 | N | N | 12.8 | 8.6 | 2561.0 | 175.8 | 2758.2 |
| 19 | 2 | 1 | N | N | 1.4 | 3.1 | 1547.0 | 149.0 | 1700.5 |
| 20 | 2 | 1 | N | Y | 9.5 | 4.3 | 3992.3 | 141.6 | 4147.7 |
| 21 | 2 | 1 | N | N | 7.3 | 27.7 | 2978.9 | 168.3 | 3182.2 |
| 22 | 2 | 1 | N | Y | 7.0 | 98.6 | 880.3 | 132.8 | 1118.7 |
| 23 | 2 | 1 | N | Y | 48.6 | 47.0 | 2063.8 | 115.8 | 2275.4 |
| 24 | 2 | 1 | N | N | 15.5 | 16.0 | 71.4 | 45.0 | 147.8 |
| 25 | 2 | 1 | N | N | 84.8 | 6.7 | 411.8 | 141.1 | 644.4 |
| 26 | 2 | 1 | N | Y | 11.1 | 1.0 | 2823.2 | 319.4 | 3154.6 |
| 1 | 1 | 1 | Y | N | 60.4 | 25.3 | 1486.0 | 9.9 | 1581.6 |
| 2 | 1 | 1 | Y | N | 239.3 | 14.1 | 1307.5 | 34.0 | 1594.9 |
| 3 | 1 | 1 | Y | N | 25.8 | 10.3 | 1442.9 | 3.5 | 1482.5 |
| 4 | 1 | 1 | Y | N | 95.5 | 12.7 | 2250.5 | 9.6 | 2368.4 |
| 5 | 1 | 1 | Y | N | 42.0 | 28.4 | 1909.5 | 11.7 | 1991.5 |
| 6 | 1 | 1 | Y | N | 251.3 | 156.7 | 2390.7 | 47.0 | 2845.7 |
| 7 | 1 | 1 | Y | N | 104.4 | 229.1 | 2181.6 | 117.5 | 2632.5 |
| 8 | 1 | 1 | Y | Y | 15.9 | 5.5 | 259.6 | 13.3 | 294.3 |
| 9 | 1 | 1 | Y | N | 24.4 | 31.3 | 1519.1 | 76.0 | 1650.7 |
| 10 | 1 | 1 | Y | N | NS | 514.4 | 2708.2 | 100.0 | NT |
| 11 | 1 | 1 | Y | N | 108.2 | 47.6 | 2461.3 | 22.2 | 2639.3 |
| 12 | 1 | 1 | Y | N | 53.8 | 10.0 | NS | 11.7 | NT |
| 16 | 2 | 2 | Y | Y | 82.9 | 21.3 | 338.2 | 20.0 | 462.4 |
| 17 | 2 | 2 | Y | N | 24.3 | 28.5 | 3161.4 | 11.5 | 3225.8 |
| 18 | 2 | 2 | Y | N | 7.4 | 6.2 | 1457.3 | 256.7 | 1727.6 |
| 19 | 2 | 2 | Y | N | 1.0 | 5.0 | 1134.9 | 29.7 | 1170.5 |
| 20 | 2 | 2 | Y | N | 19.7 | 62.7 | 1926.4 | 8.7 | 2017.5 |
| 21 | 2 | 2 | Y | N | 33.4 | 47.0 | 3585.9 | 1.8 | 3668.2 |
| 22 | 2 | 2 | Y | Y | 9.0 | 26.1 | 345.1 | 23.2 | 403.4 |
| 23 | 2 | 2 | Y | Y | 47.2 | 29.4 | 848.5 | 26.1 | 951.2 |
| 24 | 2 | 2 | Y | N | 150.9 | 76.2 | 1680.8 | 1.9 | 1909.7 |
| 25 | 2 | 2 | Y | N | 95.4 | 28.8 | 1811.7 | 10.5 | 1946.4 |
| 26 | 2 | 2 | Y | N | 5.7 | 13.6 | 1607.5 | 8.5 | 1635.4 |

NS - not samples

NT - not totaled

TABLE II

SUMMARY OF DATA FOR FIELD WORKER EXPOSURE TO CHLOROTHALONIL
WHILE PICKING BUSH GROWN TOMATOES

**Values Adjusted to Hourly Exposure in Micrograms**

| | N | MEAN | STD DEV | MINIMUM | MAXIMUM |
|---|---|---|---|---|---|
| SOCKS | 48 | 58.0 | 67.3 | 1.0 | 251.3 |
| TORSO | 49 | 61.0 | 136.4 | 1.0 | 819.3 |
| ARMS | 48 | 1835.6 | 1101.2 | 71.4 | 4655.3 |
| HANDS* | 47 | 124.8 | 128.7 | 1.8 | 526.5 |
| TOTAL | 45 | 2094.4 | 1194.0 | 147.8 | 5366.9 |

* Hands include gloved and ungloved workers and because of a significant glove effect the hand region is not representative of average exposure.

TABLE III

SUMMARY OF DATA FOR FIELD WORKER EXPOSURE TO CHLOROTHALONIL BY GLOVED AND NON-GLOVED GROUPS

**Values Adjusted to Hourly Exposure in Micrograms**

| | | N | MEAN | STD DEV | MINIMUM | MAXIMUM |
|---|---|---|---|---|---|---|
| SOCKS | GLOVE | | | | | |
| | NO | 26 | 49.5 | 65.0 | 1.4 | 250.0 |
| | YES | 22 | 68.1 | 70.1 | 1.0 | 251.3 |
| TORSO | GLOVE | | | | | |
| | NO | 26 | 59.9 | 157.3 | 1.0 | 819.3 |
| | YES | 23 | 62.2 | 111.6 | 5.0 | 514.4 |
| ARMS | GLOVE | | | | | |
| | NO | 26 | 1934.5 | 1278.6 | 71.4 | 4655.3 |
| | YES | 22 | 1718.8 | 861.2 | 259.6 | 3585.9 |
| HANDS | GLOVE | | | | | |
| | NO | 24 | 208.8 | 122.6 | 45.0 | 526.5 |
| | YES | 23 | 37.2 | 56.9 | 1.8 | 256.7 |
| TOTAL | GLOVE | | | | | |
| | NO | 24 | 2335.4 | 1381.9 | 147.8 | 5366.9 |
| | YES | 21 | 1819.0 | 889.3 | 294.3 | 3668.2 |

TABLE IV

Leaf Dislodgeable Residue For Chlorothalonil

ON BUSH GROWN TOMATOES

| ug/cm2 | Worker | Day |
|---|---|---|
| 3.77 | 1 | 2 |
| 1.89 | 2 | 2 |
| 4.30 | 3 | 2 |
| 3.62 | 4 | 2 |
| 2.00 | 5 | 2 |
| 4.88 | 6 | 2 |
| 3.15 | 7 | 2 |
| 3.62 | 8 | 2 |
| 4.56 | 11 | 2 |
| 3.44 | 10 | 2 |
| 1.46 | 16 | 1 |
| 3.98 | 17 | 1 |
| 1.94 | 18 | 1 |
| 2.06 | 19 | 1 |
| 1.07 | 21 | 1 |
| 5.57 | 22 | 1 |
| 2.82 | 23 | 1 |
| 4.63 | 26 | 1 |
| 1.17 | 10 | 1 |
| 1.14 | 11 | 1 |

Field treated twice at the rate of 1.5 pounds active ingredient per acre 5 days and 33 days before harvest.

FIGURE 1

FREQUENCY DISTRIBUTION - TOTAL EXPOSURE TO CHLOROTHALONIL
FOR WORKERS PICKING BUSH GROWN TOMATOES

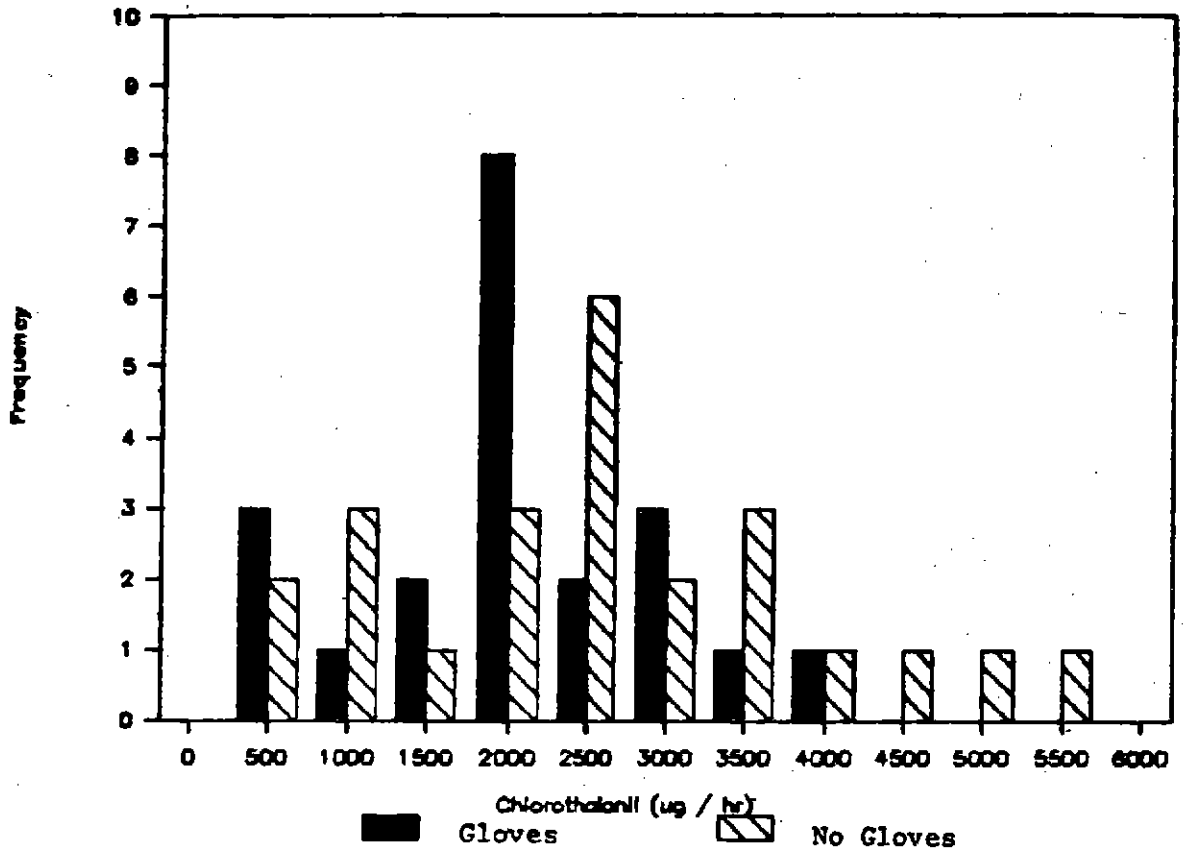


FIGURE 2

FREQUENCY DISTRIBUTION

HAND EXPOSURE TO CHLOROTHALONIL FOR WORKERS
PICKING BUSH GROWN TOMATOES

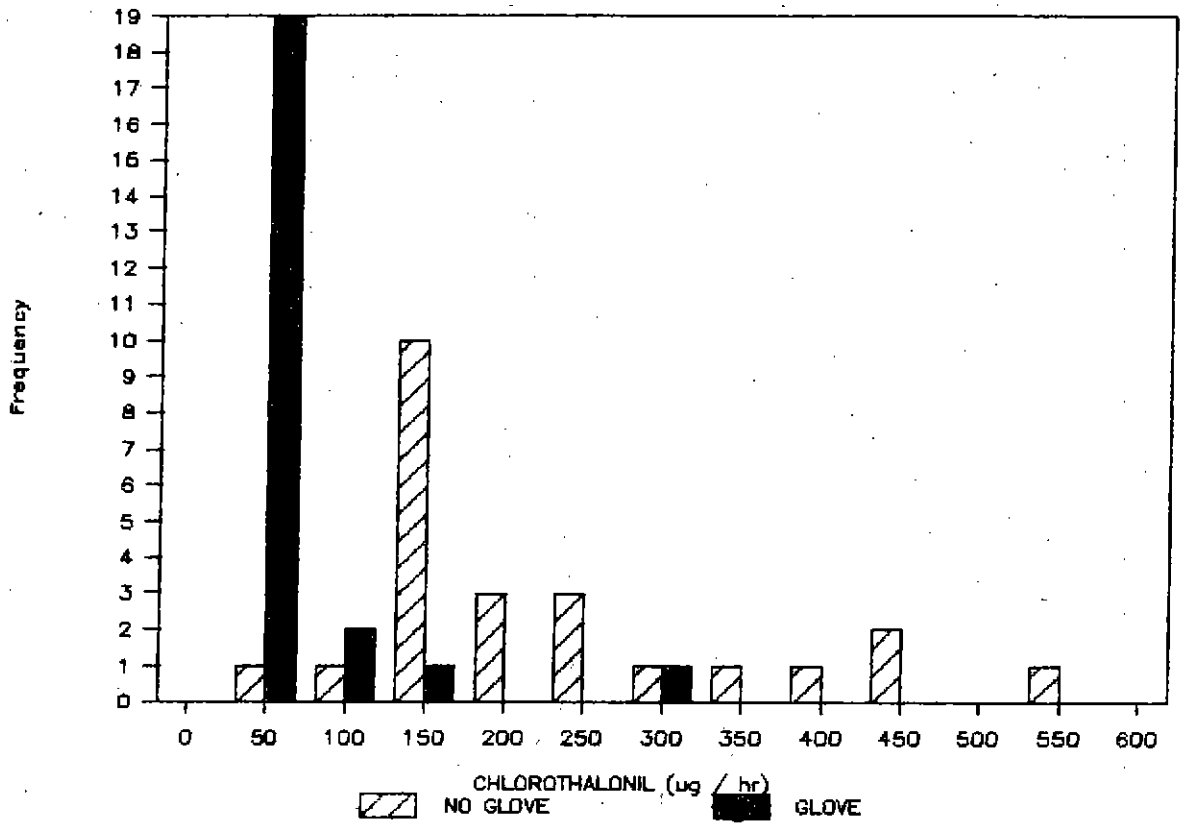


FIGURE 3

HAND WASH DATA FROM FIELD WORKERS EXPOSED TO CHLOROTHALONIL WHILE PICKING BUSH GROWN TOMATOES

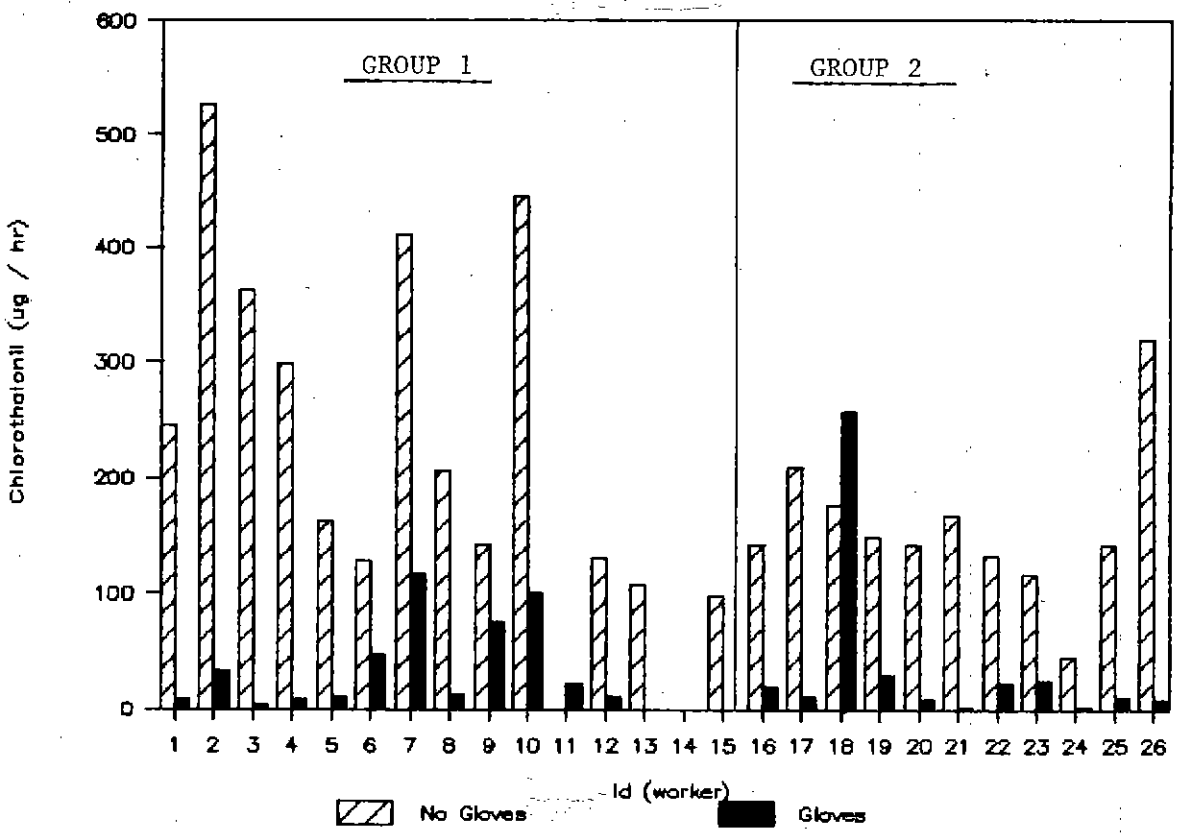
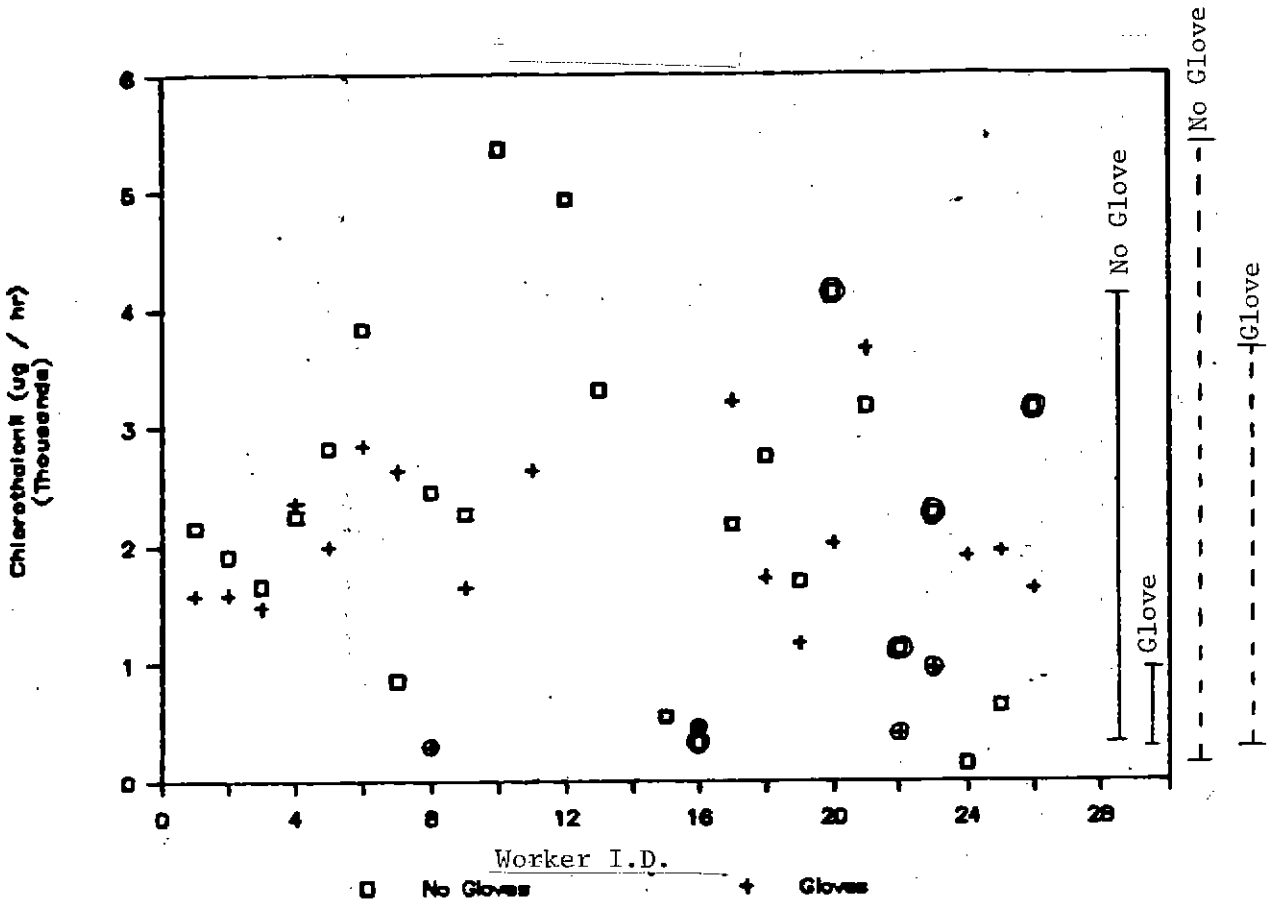


FIGURE 4

TOTAL HOURLY EXPOSURE FOR FIELD WORKERS EXPOSED TO CHLOROTHALONIL WHILE PICKING BUSH GROWN TOMATOES




□ No gloves and long sleeves ⊕ Gloves and long sleeves

Solid Bars: Ranges for workers with long sleeves.

Dashed Bars: Range for workers without long sleeves.